electrode 2020 is coupled to the negative terminal of the first pulse generator 2050, and the third electrode 2030 is coupled to the positive terminal and the fourth electrode 2040 is coupled to the negative terminal of the second pulse generator 2060. The first and second electrodes 2010 and 2020 are expected to generate a first electric field 2070, and the third and fourth electrodes 2030 and 2040 are expected to generate a second electric field 2072. It will be appreciated that the ions will be relatively free to move through the brain such that a number of ions will cross between the first and second electric fields 2070 and 2072 as shown by arrows 2074. This embodiment provides control of electric field gradients at the stimulation sites.

Figure 21 is a bottom plan view of another embodiment of the stimulation apparatus 2000. In this embodiment, the first electrode 2010 is coupled to the positive terminal and the second electrode 2020 is coupled to the negative terminal of the first pulse generator 2050. In contrast to the embodiment shown in Figure 20, the third electrode 2030 is coupled to the negative terminal and the fourth electrode 2040 is coupled to the positive terminal of the second pulse generator 2070. It is expected that this electrode arrangement will result in a plurality of electric fields between the electrodes. This allows control of the direction or orientation of the electric field.

Figure 22 is a bottom plan view that schematically illustrates a stimulation apparatus 2200 in accordance with still another embodiment of the invention. In this embodiment, the stimulation apparatus 2200 includes a first electrode 2210, a second electrode 2220, a third electrode 2230, and a fourth electrode 2240. The electrodes are coupled to a pulse generator 2242 by a switch circuit 2250. The switch circuit 2250 can include a first switch 2252 coupled to the first electrode 2210, a second switch 2254 coupled to the second electrode 2220, a third switch 2256 coupled to the third electrode 2230, and a fourth switch 2258 coupled to the fourth electrode 2240. In operation, the switches 2252-2258 can be opened and closed to establish various electric fields between the electrodes 2210-2240. For example, the first switch 2252 and the fourth switch 2258 can be closed in coordination with a pulse from the pulse generator 2242 to generate a first electric field 2260, and/or the second

switch 2254 and the third switch 2256 can be closed in coordination with another pulse from the pulse generator 2242 to generate a second electric field 2270. The first and second electric fields 2260 and 2270 can be generated at the same pulse to produce concurrent fields or alternating pulses to produce alternating or rotating fields.

Figure 23 is a bottom plan view and Figure 24 is a side elevational view of a stimulation apparatus 2300 in accordance with another embodiment of the invention. In this embodiment, the stimulation apparatus 2300 has a first electrode 2310, a second electrode 2320, a third electrode 2330, and a fourth electrode 2340. The electrodes 2310-2340 can be configured in any of the arrangements set forth above with reference to Figures 14-22. The electrodes 2310-2340 also include electrically conductive pins 2350 and/or 2360. The pins 2350 and 2360 can be configured to extend below the pial surface of the cortex. For example, because the length of the pin 2350 is less than the thickness of the cortex 709, the tip of the pin 2350 will accordingly conduct the electrical pulses to a stimulation site within the cortex 709 below the pial surface. The length of the pin 2360 is greater than the thickness of the cortex 709 to conduct the electrical pulses to a portion of the brain below the cortex 709, such as a deep brain region 710. The lengths of the pins are selected to conduct the electrical pulses to stimulation sites below the pia mater 708. As such, the length of the pins 2350 and 2360 can be the same for each electrode or different for individual electrodes. Additionally, only a selected portion of the electrodes and the pins can have an exposed conductive area. For example, the electrodes 2310-2340 and a portion of the pins 2350 and 2360 can be covered with a dielectric material so that only exposed conductive material is at the tips of the pins. It will also be appreciated that the configurations of electrodes set forth in Figures 14-22 can be adapted to apply an electrical current to stimulation sites below the pia mater by providing pin-like electrodes in a matter similar to the electrodes shown in Figures 23 and 24.

Several embodiments of the stimulation apparatus described above with reference to Figures 6-24 are expected to be more effective than existing transcranial or subcranial stimulation devices. In addition to positioning the electrodes under the

skull, many embodiments of the stimulation apparatus described above also accurately focus the electrical energy in desired patterns relative to the pia mater 708, the dura mater 706, and/or the cortex 709. It will be appreciated that transcranial devices may not accurately focus the energy because the electrodes or other types of energy emitters are positioned relatively far from the stimulation sites and the skull diffuses some of the energy. Also, existing subcranial devices generally merely place the electrodes proximate to a specific nerve, but they do not provide electrode configurations that generate an electrical field in a pattern designed for the stimulation site. Several of the embodiments of the stimulation apparatus described above with reference to Figures 6-24 overcome this drawback because the electrodes can be placed against the neurons at the desired stimulation site. Additionally, the electrode configurations of the stimulation apparatus can be configured to provide a desired electric field that is not diffused by the skull 700. Therefore, several embodiments of the stimulation apparatus in accordance with the invention are expected to be more effective because they can accurately focus the energy at the stimulation site.

4. Implantable Stimulation Apparatus with Biasing Elements

Figures 25-30 illustrate several embodiments of stimulation apparatus having a biasing element in accordance with a different aspect of the invention. The stimulation apparatus shown in Figures 25-30 can be similar to those described above with reference to Figures 6-24. Therefore, the embodiments of the stimulation apparatus shown in Figures 25-30 can have the same pulse systems, support members and electrode configurations described above with reference to Figures 6-24.

Figure 25 is an isometric view and Figure 26 is a cross-sectional view of a stimulation apparatus 2500 in accordance with an embodiment of the invention. In one embodiment, the stimulation apparatus 2500 includes a support member 2510, a pulse-system 2530 carried by the support member 2510, and first and second electrodes 2560 coupled to the pulse system 2530. The support member 2510 can be identical or similar to the support member 610 described above with reference to Figures 6 and 7. The support member 2510 can accordingly include a housing 2512